Field Stations

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

546.1

Project | Date | Author

TITLE

FOREST INSECT LABORATORY
FORT COLLINS, COLORADO
MAR 11 1949
BUREAU OF ENTOMOLOGY & PLANT QUARANTINE U. S. DEPT. OF AGRICULTURE

Report on Aerial Spraying Experiments for the Control of the Yellow-headed Spruce Sawfly

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January 6, 1949

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Terrell – 4/11/49
Evenden – 4-11-49

SUBJECT—

INDEX No.—

U. S. GOVERNMENT PRINTING OFFICE 16—47272-1

546.1 file

also card under 3451.3

Report on Aerial Spraying Experiments for the Control of the Yellow-headed Spruce Sawfly.

By J. V. Schaffner, Jr. and Robert Heller, Div. Forest Insects Investigations USDA and Joel W. Marsh, Assistant State Entomologist of Maine.

The yellow-headed spruce sawfly, Pikonema alaskensis (Roh.), was originally described by S. A. Rohwer (1) in 1911 from specimens collected in Alaska. Apparently it is distributed through most of the spruce regions in the United States and Canada. Nash (2) studied this insect in Maine and published on its life history and habits in 1939.

Until July 1947 when a severe outbreak was reported in Sagadahoc County, Maine, in natural stands of red spruce, (much of which was mature) the only outbreaks, so far as known, have been rather local and had occurred on young open growth in plantations and stands of natural reproduction and also along edges of closed stands.

Immediately following receipt of the report that spruce trees in Sagadahoc County were being severely defoliated State Entomologist H. B. Peirson and assistants investigated and found some 1600 acres of red spruce infested, in the Townships of Georgetown and Phippsburg. These spruce areas, for the most part, are in blocks ranging from 10 to 150 acres on peninsulas and coastal islands, many of which are owned by summer residents.

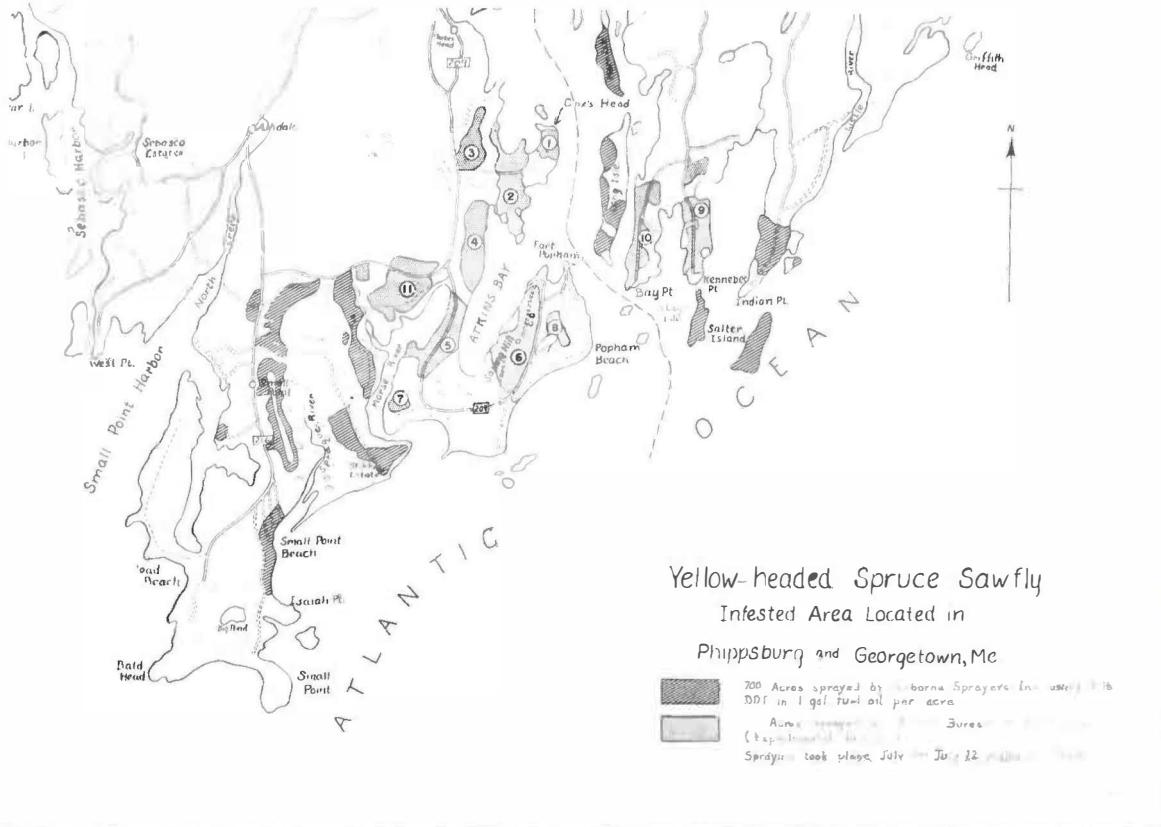
It is generally believed that the outbreak started on Sabina Hill, near Fort Popham, some three or four years ago. There are some 140 acres of spruce, ranging up to 15 or 18 inches D.B.H., on this hill and many of the trees had been severely defoliated in 1946 and 1947. Although the degree of defoliation has varied considerably from tree to tree, there is one area of about 25 acres in this stand where at least 80 percent of the spruce are dead or dying, and throughout this entire stand

and in other nearby stands there is a scattering of dead or bauly weakened spruce trees as a result of the defoliation. The unevenness in the degree of defoliation can be explained by the facts that there is a variation, from tree to tree, of several days in the time of the opening of the buds, and that the females are ready to lay their eggs between the needles on the new growth just after the earliest bud scales are cast off. Those trees late in foliating, therefore, have fewer eggs deposited on the needles and suffer least defoliation by this insect. The larvae, in the early instars, feed only on the new growth of the current year, but in later instars they feed on both the new and the old needles.

Because of the seriousness of the situation, not only from the standpoint of the value of the timber as a crop, but also the aesthetic value of the spruce on and adjacent to shore property both public and privately owned, and used by summer residents, Mr. Peirson was called on to consider the application of control measures. Inasmuch as no large scale measures of control have ever been applied against this insect Mr. Peirson requested the cooperation and assistance of the Division of Forest Insect Investigations in making some aerial applications of insecticides on an experimental basis. He assigned Assistant State Entomologist Joel W. Marsh to survey the infested areas, and to contact Town Officials and property owners relative to the appointment of committees and the raising of funds to defray the expenses of spraying. Altogether some $1050.00 were contributed by the State, Towns, and private property owners. This sum was used in a contract with the Airborne Sprayers, Inc. for spraying a total of 700 acres.

In addition some 727 acres were selected and divided into 11 plots for experimental airplane spraying by the Division of Forest Insect Investigations, U.S.D.A., in cooperation and with the assistance of the State Entomologist and his staff. (See accompanying map) The areas most severely infested were selected for these experiments so that the results of the spraying could be definitely measured.

Establishment of the spray plots. It has already been mentioned that the infested areas were situated on coastal peninsulas and islands in Sagadahoc County, Maine, and that the spruce stands, for the most part, were in blocks ranging from about 10 to 150 acres in extent. These areas were bounded by either water, salt marsh, or stands of hardwoods and occasionally some pitch pine and white pine, so it was most practicable to use these natural bounds in laying out the plots rather than attempt to establish plots of equal size. The acreages were determined from an aerial photograph which was taken during the recent war. The bounds of the plots were so well defined that it was not necessary to mark the corners of any of them.


Griffith Head
Chas Head
Sebasco Estates
Windale
Fort Popham
Bay Pt
Kennebec Pt
Indian Pt
Salter Island
Popham Beach
West Pt.
Small Point Harbor
ATKINS BAY
ATLANTIC OCEAN
Small Point Beach
Bald Beach
Isaiah Pt
Bald Head
Small Point
N
Yellow-headed Spruce Sawfly
Infested Area Located in
Phippsburg and Georgetown, Me
700 Acres sprayed by [illegible] DDT in 1 gal fuel oil per acre
Spraying took place July [illegible] 12

Plans and Objectives

It has been established that certain sawfly larvae can be controlled by the aerial application of DDT in a dosage of one pound in one gallon of fuel oil per acre, so the purposes of this experiment were to test the possibility of reducing the dosage and to test the effectiveness of particle size when standard nozzles (B5) were used as compared to fine nozzles (B2). The standard application was to be at the rate of 1/4 pound of DDT in 1/2 gallon of fuel oil per acre.

DDT solutions were used on 10 plots and an emulsion on one plot.

Table I lists the plots by number and local name of each, the acreage, the type and number of nozzles used for spraying each plot, the dosages and the dates of application.

Table I.

Plot No.	Local name of area	Acreage	Type and Number of Nozzles		Dosage DDT-Fuel Oil	Date Applied 1948
			No.	Type		
1	Cox' Head	24	15	B-5*	1/4 lb-1/2 gal	7/8
2	Middle Cox's Head	68	30	B-2	do	7/10
3	McLanathan's	43	15	B-5	do	7/10
4	N.W. of Atkins Bay	79	15	B-5	do	7/9
5	Between Morse River and Atkins Bay	99	15	B-5*	do	7/9
6	Sabina Hill	140	15	B-5	do	7/9
7	Island, near Morse River	24	15	B-5	do	7/9
8	Popham Pond	20	15	B-5	do	7/9
9	Bay Point	65	30	B-5	1/2 lb-1 gal	7/12
10	Kennebec Point	75	30	B-5	1/2 lb-1 gal(emul)	7/12
11	North of Morse River	90	8	B-5**	1/4 lb-1/2" (oil)	7/10
		727 acres				

* Plots 1 and 5 were reflown on 7/12/48 with 30 B-5 nozzles - 1/2 lb DDT in 1 gal. fuel oil. (Total dosage)for these plots being 3/4 lb. DDT in 1 1/2 gal. fuel oil)

** Area was flown twice; swaths at 90° to each other.

Equipment and Supplies

The Division of Forest Insect Investigations, U.S.D.A., furnished a Stearman biplane piloted by Robert Heller for making the applications. The nozzles were evenly spaced along the boom in all cases except when 30 nozzles were used. With this nozzle arrangement two-thirds of the nozzles were placed on the outboard half of each boom.

Helium filled balloons were used for marking the swaths in the larger plots and where roads were accessible on the smaller plots; 7 of the 11 plots were balloon-marked.

Short wave radio equipment, operated by Messrs. Socrist and Hartmeyer of the Beltsville Station of this Division, was tested for communication between the areas to be sprayed and the airport. The reception was not entirely satisfactory partly because of mechanical difficulties. Apparently some of the mechanism was too delicate for transportation over rough country roads. The development of radio communication for use in airplane spraying operations is sorely needed, as it would save considerable time and expense in these operations.

The Division of Gypsy and Brown-tail Moths Control, U.S.D.A., furnished a power mixing machine operated by Ralph Holbrook. This equipment not only mixed the spray materials thoroughly but with its meter, exact quantities of the solutions and emulsions needed for each flight were measured as they were pumped into the plane. The assistance rendered by Holbrook on this project was greatly appreciated.

The DDT, the solvent, and emulsifying agent for the experiments were furnished by the Bureau of Entomology and Plant Quarantine, and the fuel oil by the Entomology Department of the State of Maine Forest Service.

Data on status and degree of infestation

It is difficult to obtain a fair estimate of the population of an insect such as the yellow-headed spruce sawfly. The cocoons are formed more or less in pockets in the soil and beneath rocks, and are not evenly distributed beneath the host trees. The eggs are thrust between the needles on the new growth just as soon as the bud scales are cast off. The opening of all buds on individual trees are not simultaneous, also there is a considerable difference from tree to tree, and because of this the infestation is not evenly distributed in a stand.

Late in May and in June, Marsh made some examinations in areas where considerable feeding had occurred in 1947 to obtain data on the status of the infestation. The results of these examinations are summarized as follows:

Table II.

Site of collection and Date-Week of May 24th	Approx-imate area examined	No. of cocoons	Results of analysis of cocoons: Prepupal larvae Living	Prepupal larvae Dead	Living pupae	Sawflies emerged new	Sawflies emerged old	Parasitized Living	Parasitized dead	Parasitized emerged old	Cocoons with holes Predators(?) New	Cocoons with holes Predators(?) old
Sabina Hill	1 sq.ft.	50	22	12	2	0	8	0	0	1	0	5
" "	1 sq. ft.	57	26	13	5	0	7	2	0	4	0	0
St. John Est.	2 sq.ft.	46	14	8	6	0	6	6	0	2	0	4
Cox's Head June 1 & 2	Several	32	4	12	12	0	4	0	0	0	0	0
Bay Point	3 sq.ft.	143	13	28	22	0	62	13	2	0	3T	0
" "	2 " "	113	17	47	25	2*	9	10	1	0	2T	0
Kennebec Pt.	½ " "	55	6	18	23	2*	0	2	0	3	1T	0
Totals		496	102	138	95	4	96	33	3	10	6	9

* - Adults about to emerge

T - Cocoons torn open.

Marsh found some adults active in the Phippsburg area on June 10th, and observed that buds on red spruce growing in openings and along edges of stands were about 1/2 inch in length, but on red spruce timber trees and in shaded areas the buds were only slightly swollen. Larvae of this sawfly were in the second instar on this date in the vicinity of Augusta but no hatching had occurred up to and including June 22nd in the Phippsburg infestation.

During the week of June 28th the hatching was well advanced on red spruce in open areas in Phippsburg and Georgetown. First and second instar larvae were observed, and the feeding on the new growth of red spruce was noticeable in these areas. However, in areas heavily shaded and where the ground was wet, the red spruce buds were just beginning to open, and there was considerable activity of sawfly adults; - on the wing, copulating, and laying eggs. A collection of cocoons on Sabina Hill revealed that a small percentage of the cocoons still contained living prepupal larvae.

The results of the field observations disclosed that heavy defoliation was imminent, and that in order to prevent serious injury spraying operations should begin the week of July 6th.

Spray Applications

Spraying operations were begun on July 8th and were completed on the 12th. The weather, for the most part, was favorable and the coverage seemed to be complete. Information on the dosages, size of plots, and dates of application is given in Table I. One plot (No. 11) was flown twice, as originally planned, the swaths at 90° to each other, to obtain data on the difference in results when the same amount of spray per

acre was used on plots flown once. Two plots (Nos. 1 and 5) were re-flown because the first spray application did not give satisfactory control.

Methods used to determine results

Dead larvae and samples of frass were collected on 3' x 3' cloth trays, 5 to 15 trays to each plot. The trays have collapsible frames for ease in transporting and distributing; one man being able to carry a bundle of 10 trays over rough forest terrain. This collapsible tray, developed by J. E. R. Holbrook of the New Haven Station, proved to be very practical. They save on transportation because of the decrease in bulk, are easily handled in the forest and the cloths are easily removed for washing.

The trays were placed beneath host trees showing evidence of larvae just prior to spraying in order to obtain samples of the larval excrement and to record the dead larvae. A card having a square inch hole cut in it was used as a measure when counting the excrement pellets. The card was moved from place to place on the trays and all pellets showing in the square inch hole at each move were counted in order to obtain an average of the excrement deposit on each tray. The success or failure of the spray treatments were based on the number of dead larvae removed from the trays and the decrease or increase of larval excrement found over a period of two weeks's examination following the spraying.

Table III.

Data on the average number of excrement pellets per square inch of tray surface

(A) Plots sprayed at rate of 1/4 lb. DDT in 1/2 gal. of solution

Plot No.	Acreage	DDT	Sol.	Time	Date Sprayed	Nozzles No.	Nozzles Type	No. frass trays	Date of examinations and average number pellets per square inch of trays. July 10	12	14	16	19	21	23	26
2	68	1/4 lb.	1/2 gal.	AM	July 10	30	B2	10		29	4	11	15	11	7	
3	43	"	"	"	10	15	B5	5		24	9	5	5	4	3	
4	79	"	"	"	9	15	B5	10	55	40	21	14	15	13	12	
6	140	"	"	"	9	15	B5	15	-	19	9	5	5	4	3	
8	20	"	"	"	9	15	B5	5	-	18	9	6	6	6	4	
11	90	"	"	"	10	8	B5[a]	10		28	7	8	11	8	7	

a - Area flown twice same day. Swaths at 90° to each other.

(B) Plots sprayed at rate of 3/4 lb. DDT in 1 1/2 gal. of solution

									July 10	12	14	16	19	21	23	26
1	24	(1/4 lb.	1/2 gal.	PM	July 8	15	B5	5	Not measured	38	20	21	21	14	19[b]	
		(1/2 lb.	1 gal.	AM	12	30	B5									
5	99	(1/4 lb.	1/2 gal.	AM	9	15	B5									
		(1/2 lb.	1 gal.	AM	12	30	B5	10	122	50	25	15	19	19	16	12

b - Power company blasted post holes, so figures for this date not significant as frass may have been jarred from foliage.

(C) Plots sprayed at rate of 1/2 lb. DDT in 1 gal. (solution vs. emulsion)

									July 13	15	17	20	22	24	26
9	65	1/2 lb.	1 gal.sol.	AM	July 12	30	B5	10		36	26	31	41	32	35	12
10	75	1/2 lb.	1 gal.emul.	AM	12	30	B5	10		52	50	46	63	55	53	32

Table IV

Mortality data from plots sprayed at rate of 1/4 lb. DDT per acre[a]

Plot No.	Acreage	DDT	Sol.	Time	Date Sprayed	Nozzles No.	Nozzles Type	No Trays	Date in July when examinations were made. Average number of larvae per tray (3' x 3' in size) 9	10	12	14	16	19	21	23	26	Average Number larvae per tray
2	68	1/4 lb.	1/2 gal.	AM	July 10	30	B2	10	-	-	18.1	6.5	1.7	1.4	0.5	2.9*		31.1
3	43	"	"	"	10	15	B5	5	-	-	53.0	12.6	2.6	2.2	0.4	0.6*		71.4
4	79	"	"	"	9	15	B5	10		69.8	31.8	33.3	10.8	7.2	1.5	5.8*		160.2
6	140	"	"	"	9	15	B5	15		9.8	11.9	4.3	2.8	2.3	0.5+	1.4*		33.0
8	20	"	"	"	9	15	B5	5		5.8	11.4	3.0	1.2	1.6	1.0	1.2*		25.2
11	90	"	"	"	10[a]	8	B5[a]	10			33.8	2.9	2.2	1.9	0.4	1.2*		42.4

Mortality data from plots sprayed at rate of 3/4 lb. DDT per acre (Flown twice)

									July 9	10	12	14	16	19	21	23	26	
		1/4 lb.	1/2 gal.	PM	July 8	15	B5	5	59.4	45.4	25.8							222.8
1	24	1/2 lb.	1 gal.	AM	12	30	B5					73.2	8.2	2.4	1.8	6.6*		
		1/4 lb.	1/2 gal.	AM	9	15	B5	10		180.2	70.8							
5	99	1/2 lb.	1 gal.	AM	12	30	B5					158.5	25.7	11.2	3.6	31.4*	21.8*	503.2

Mortality data from plots sprayed at rate of 1/2 lb. DDT per acre (solution vs. emulsion)

									July 13	15	17	20	22	24	26	
9	65	1/2 lb.	1 gal.	sol. AM	July 12	30	B5	10	129.4	30.4	10.7	4.6	2.8*	1.8*	0.7	180.4
10	75	1/2 lb.	1 gal.	emul. AM	12	30	B5	10	35.4	14.1	3.8	1.6	1.8*	1.0*	1.4	59.1

a - Plot 11 flown twice same day; swaths at 90° to each other
* - Rained in PM July 21 and 23. Many dead larvae presumably washed from foliage.
\+ - July 21 - 1 tray stolen and 3 trays disturbed.

Table V.

Data from two areas sprayed by Airborne Sprayers, Inc. sprayed at rate of 1 lb. DDT in 1 gal. of solution

(A) Excrement pellets per square inch of tray surface

Area	DDT	Sol.	Date Sprayed	No. Trays	Date trays put out	Dates examined Average No. frass pellets per sq. in. of tray 15	19	20	21	23
Long Island	1 lb.	1 gal.	July 9	5	July 14	16	-	15	-	-
St. Johns Est.	1 lb.	1 gal.	10	5	14	8	35	-	27	18

(B) Mortality data

Area	DDT	Sol.	Date Sprayed	No. Trays	Date trays put out	Dates examined Average number dead larvae for tray 15	19	20	21	23
Long Island	1 lb.	1 gal.	July 9	5	July 14	5.2	-	4.2	-	-
St. Johns Est.	1 lb.	1 gal.	10	5	14	1.4	1.3	-	1.4	1.0

Analysis of Data

An analysis of the data shows that complete control or 100 percent mortality, was not obtained in any of these experiments. Possibly another week's observations and counts of the droppings on the trays would have aided in drawing more definite conclusions. At the beginning of these experiments, however, it was estimated that sufficient data could be gathered to determine the effectiveness of the sprays if the examinations of the trays in each plot were continued for a period of two weeks following the date of spraying, and this was carried out as planned.

The data summarized in table III show that considerable excrement was dropping on some of the trays at the termination of observations. Because of the wide difference in degree of infestation from tree to tree, and also from one plot to another, a considerable difference in the number of excrement pellets per square inch of tray was expected during and at the termination of examinations, unless a 100 percent mortality was obtained. Although DDT was applied at rates per acre of 1/4 lb. in 1/2 gallon, 1/2 lb. in one gallon, and 3/4 lb. in 1 1/2 gallons of solution and 1/2 lb. in one gallon of emulsion, the difference in results obtained are not striking.

An analysis of the data in table IV shows that 80 to 95 percent of the larval mortality occurred within from 4 to 6 days following the spray applications. In plots 1 and 5 there was a tremendous increase in the numbers of dead larvae dropping onto the trays following the second spray application, which was made four days after the first application. As the first applications were made under favorable conditions and in a manner as near as possible to those of plots 3, 4, 6, and 8, the results indicate rather definitely that 1/2 gallon of solution per acre does not give adequate coverage on trees with long crowns such as the red spruce in these plots. In con-

sidering the data from the trays one must also take into consideration that many of the dead larvae and pellets of excrement lodge on the branches between the needles of spruce and do not drop until winds or rains dislodge them. This undoubtedly explains some of the increases in the tray records following the rains on July 21st and 23rd.

Little time was available for checking on the results obtained by the commercial company. Ten trays were put out, 5 in each of two spruce areas, four or five days after the areas were sprayed. The standard dosage used on these areas was one pound in one gallon of solution. Although these areas, in general, had much lighter infestations than those selected for experimental purposes, the results of the tray examinations as given in table V show definitely that one pound of DDT in one gallon of solution did not give 100 percent control.

The sprays in all cases prevented serious defoliation, even in the heavier infested areas. Although some defoliation is noticeable on individual trees in plots which received up to one half pound of DDT per acre, the trees in these spots were known to have been heavily infested, and their condition now would have been much worse had they not been sprayed.

- Summary -

The results of observations show that the beginning of egg laying coincides with that of the opening of the first buds on red spruce. The eggs are thrust down between the new needles as soon as the bud scales are cast off, and because of the unevenness of the opening of the new growth on spruce the infestation differs considerably from tree to tree. In 1948, egg laying began about the middle of June in the vicinity of Georgetown and Phippsburg, Maine, and continued through the first week of July. Hatching apparently started about the fourth week in June and continued to about the middle of July.

It is very evident that light dosages of DDT will kill larvae in the early instars. Proper timing of the spray applications is of tremendous importance because of the variation from tree to tree in the opening of the new growth, and because of the difference in time of hatching. The young larvae feed only on the new needles, and do not move about much until they are about half grown. Therefore, in order to obtain close to one hundred percent mortality by spray, adequate coverage is necessary. It is evident from these experiments that 1/2 lb. of DDT in one gallon of solution or emulsion prevented serious defoliation in medium to heavy infestations, but it is also apparent there are many survivors. In order to obtain near perfect control it may be necessary to use at least one pound of DDT in two gallons of spray, because of the size of the crowns of red spruce.

1) Rohwer, S. A.
1912 - New Sawflies in the Collection of the United States National Museum. U. S. Nat. Mus. Proc. 41: 377-411

2) Nash, R. W.
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FEB 7 1949
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